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Spitzbergen and Nova Zembla, not knowing anything about warm currents, gave rise to the belief that the climate at the Pole was exactly like that of Amsterdam in summer.

I hope that an exploring expedition will be sent towards the Pole, east of Greenland; but I think it would be prudent to send steamers every year to Spitzbergen and to Nova Zembla, leaving England in the middle of May, and to be well acquainted with the condition and the movements of the ice before venturing any sledge-expeditions on the Polar pack, north of 82°.

2. *Account of the Scientific Results of the Arctic Expedition under the Command of Dr. Isaac I. Hayes.* By Dr. I. I. HAYES.

Extracted from the Proceedings of the American Philosophical Society,
December, 1861.

THE only published account of Dr. Hayes' important expedition to Smith Sound in 1860-61, in which he attempted to extend the explorations commenced by his predecessor Dr. Kane, appears to be the following report of a paper which he read before the American Philosophical Society on the 6th of December, 1861. The Report being little known or accessible to English geographers, the following reprint of it will doubtless be acceptable. It is necessary to bear in mind that Dr. Hayes had accompanied Dr. Kane as surgeon in the memorable expedition of 1853-5:—

Upon leaving Boston, July 10th, 1860, my entire party numbered only fifteen persons, and we sailed in a schooner of only one hundred and thirty-three tons burden. My purpose was to follow up the line of research opened by Dr. Kane. I allude, of course, to that of Smith Strait and Kennedy Channel. You will readily understand that I had no such idle purpose as was sometimes popularly attributed to me, viz., that of merely reaching the North Pole of the earth, as a feat of adventurous navigation and sledging. The general object was to procure as much information as the restrictions of our voyage would allow, beyond the termination of Dr. Kane's labours, and in the same direction in which they tended. The space between the point at which his personal observations ended and the North Pole, is about six hundred and fifty miles, an interval sufficiently large to admit of very numerous and important collections. Coinciding with him in the opinion that at some portion of each year there exists a large body of water about or near the Pole, I hope to extend the evidence which he had collected on this subject as well as on many others. It would, of course, have been a source of the highest satisfaction to have succeeded in settling at rest the question of open water, but it was by no means the sole object of the Expedition.

I will not dwell upon the details of our voyage to Greenland, which was unusually boisterous. The schooner was unavoidably so heavily laden that her deck was never more than 18 inches above the water, and was never dry. After touching at Pröven and Upernivik, we reached, on the 21st of August, Tессuissak, the most northern of the Danish stations, in latitude 73° 40'. At all of these places we were kindly received, and the officials furnished me with every facility in their power for procuring the requisite furs and dogs for sledge travelling. Our route lay thence northward through Melville Bay, the general

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track of the whalers. Beyond the parallel of the Carey Islands, near which the whalers annually pass, and thence to Smith Strait, our track was the same as that of Dr. Kane. The distance from the northern limit of the whale fishery to Smith Strait, you will perceive, is not great, and with a fair wind we ran it in a few hours. The chief interest of our voyage commences, therefore, on the 26th of August, on which day we were a little to the northward of the position of Baffin in 1616, and Ross in 1818, 20 miles south of Cape Alexander, the entering cape on the Greenland side of Smith Strait.

The Strait was entered on the 27th of August; but we were unfortunate in meeting near its mouth an ice-pack of extraordinary thickness, through which no passage could be effected. This pack trended off to the south and west, and appeared to adhere to the western coast. Our efforts to find a navigable lead were interrupted by a heavy gale, which broke suddenly upon us and drove us out of the Strait. The gale continued with great force for three days, during which we were a second time driven out of the Strait, and having at length sustained serious damage, we made the land and anchored. At that place I went on shore, and from an elevation of 1200 feet obtained a view to the west and north. The ice was everywhere closely packed and heavy. On the following day we were blown from our anchorage, and were much damaged against some icebergs which had drifted in with the current. It was as late as the 1st of September that we again entered the Strait, again to be blown out and crippled by a sudden return of the gale. It was not until the evening of September 2nd that we effected a permanent lodgement in the Strait. Failing to find an opening toward the west shore, I determined to seek one higher up near Cape Hatherton; but, when among the ice off Littleton Island, the schooner became "beset," the iron sheathing on the bows and the cutwater was carried away, and the rudder was rendered useless. After some hours we reached a place of safety and anchored. We put to sea again on the 6th; but failing to pass Littleton Island, and the temperature having fallen to 12° , when navigation was no longer safe, I was obliged to go into winter quarters in Hartstein Bay, 10 miles north-east of Cape Alexander, in a harbour which I have named Port Foulke, in honour of my friend, William Parker Foulke, Esq., of Philadelphia, a member of this Society, who was the earliest and has been one of the most constant friends of the Expedition. Subsequent observations gave our position latitude $78^{\circ} 17' 41''$, longitude $72^{\circ} 30' 57''$ w., 20 miles south of the latitude of Rensselaer Harbour (Dr. Kane's winter quarters), and distant from it by the coast line about ninety miles.

At the time of going into winter quarters my vessel was badly crippled by frequent collisions with field ice, and by twice being driven upon icebergs. The weather was not only very boisterous from the time of our first entering the Strait, but thick snow was almost continually falling. I regretted very much that I had not steam-power. My plans of exploration being based upon reaching the west coast and there obtaining a harbour above or near latitude 79° , which I had thought practicable from personal observations made in 1854, you will perceive that my winter harbour was very unfavourable for the accomplishment of my purpose. I could not attain even as convenient a position as that of Dr. Kane, whose line of travel being near the Greenland coast, was freed from some of the obstacles attending my passage across the Strait, with dog sledge, to Grinnell Land. Our preparations for the winter were similar to those of Dr. Kane. A house was built on shore to receive our stores, and the hold of the vessel was converted into a room for the men. The upper deck was covered with a house made of boards which had been brought for the purpose. The ship's company lived in health and comfort. With the winter, however, came serious misfortunes. A disease which had been for several years prevailing throughout all Northern Greenland broke out among my dogs, and by the middle of December all of them had died but eleven. It became then necessary

to open communication with the Esquimaux of Whale Sound, with the view of obtaining a new supply. It will be remembered that my plans of exploration were based entirely upon the use of dogs as a means of transportation across the ice; and from my unfavourable situation it appeared evident that with my reduced force I had not the means to prosecute my purposes with the success which I had anticipated.

Mr. Sonntag early volunteered to go to the Esquimaux for the purpose before named. His offer was accepted, and he started on the 22nd of December, with a sledge drawn by nine dogs, and accompanied by Hans (Dr. Kane's young native hunter), whom I had found at Cape York. Mr. Sonntag lost his life in attempting to cross Whale Sound, under the following melancholy circumstances, as reported to me by Hans upon his return. In attempting to cross a crack which had been recently frozen over, Mr. Sonntag broke through the thin ice and became thoroughly wetted. He was assisted out of the water by his companion, but before they could reach a place of shelter, five miles distant, Mr. Sonntag was so badly frozen that he was insensible, and he died soon afterwards. The body was subsequently recovered and interred near the observatory at Port Foulke. Hans continued southward and accomplished one of the purposes of the journey; but, in consequence of bad management and over-driving, five dogs of his team were killed, and I was left, upon his return, with only six animals. The Esquimaux having learned through Hans of our being at Port Foulke, came to us in the spring, and from them I was enabled to obtain a sufficient number of dogs to increase my pack to about twenty animals; but some of them died afterwards, and I was left, finally, with two teams of seven each. With so reduced a force, I became seriously apprehensive for the success of the labours which were to follow.

On the 20th of March, I set out on my first journey. The object of this effort was to establish a provision depot for use during the summer, and it was successful. While absent upon this occasion I visited Rensselaer Harbour, Dr. Kane's winter quarters. No vestige of the *Advance* could be discovered. She has probably drifted out to sea with the ice, and been subsequently crushed and sunk.

The preparations for the principal journey were completed early in April; and on the 4th of that month I started northward with my entire available force, comprising twelve men and fourteen dogs. Our equipment consisted of a metallic lifeboat mounted on runners, provisions for seven persons for five months, provisions for six persons and fourteen dogs for six weeks, and the necessary camp fixtures. That part of my plan involving the transportation of the boat to Kennedy Channel proved, after three weeks' trial, to be impracticable, and I accordingly sent the main party back, and continued northward with the two dog-sledges and three companions. After a journey beset with unusual difficulties, the west coast was reached on the 10th of May, and I continued thence northward along that coast until May 18th, when, my provisions being exhausted, I was obliged to return. We had then reached latitude $81^{\circ} 35'$. During the last few days of my northward journey, I was, in consequence of the severe labour having broken down the other members of my party, accompanied only by a young Philadelphian, Mr. George F. Knorr, who served with great fidelity and spirit throughout the Expedition. The schooner was broken out of the ice on the 10th of July, and we put to sea on the 14th. After much difficulty and two trials, we reached the west coast, 10 miles below Cape Isabella. That cape I was unable to pass in the vessel, but I succeeded in making its north side in a whale-boat, and from an elevation of about 600 feet, I obtained a view to the northward. In that direction the ice was everywhere unbroken; and as it did not appear probable that I could obtain for the schooner a more northern harbour, and as I had now only five dogs remaining, I abandoned the field and returned home, trusting to be able at an early day to renew the attempt with a small steamer.

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We reached Upernivik on the 14th of August, and Godhavn, Disco Island, September 1st. At both of these places we were kindly and hospitably received by the Danish officials. At the latter place I had the satisfaction to meet the Royal Inspector, Mr. Olrik, an honorary member of this Society. Upon reaching Godhavn, I was kindly informed by Inspector Olrik that he had received orders from his Government, framed in accordance with a request made by the Government of the United States, directing him to afford such aid to the Expedition as was in his power; and it gives me great pleasure to be able, on an occasion like the present, to acknowledge the important services rendered to the Expedition by the Danish Government, and its officials in Greenland—exhibiting that characteristic generosity and intelligent appreciation which have uniformly marked their actions towards all previous explorations of a similar nature. Our voyage from Godhavn southward was very stormy, and, when off Halifax, such damages were suffered as required us to put into that port for repairs. Our welcome there was very cordial and highly grateful to us. The Admiral of Her Britannic Majesty's fleet, then in Halifax Harbour, generously tendered the use of the Government conveniences for repairing my crippled vessel. To the officers of Her Majesty's civil Government, and of the squadron and garrison, and to the citizens of Halifax, the Expedition is indebted for attentions which exhibited not less a friendly feeling for men who had for so long a time been deprived of many of the comforts of civilization, than respect for the flag under which our explorations had been made. Having sailed from Boston, I considered that a proper respect for those who gave me the vessel required that I should return to that port. Leaving Halifax on the 19th of October, we arrived in Boston on the 23rd, after an absence of fifteen months and thirteen days.

I have dwelt thus at length upon the narrative of the Expedition, in order that you may have a clear understanding of the region covered by it. I will now pass to a brief statement of the results of our labours. Soon after entering our winter harbour, an observatory was erected upon shore near the vessel, under the superintendence of Mr. Sonntag. It was a frame structure, covered first with canvas and then with snow, and was eight feet square. In this, a fine pendulum apparatus, constructed under Mr. Sonntag's supervision, by the Messrs. Bond of Boston, after the plan of Foster's instrument, was immediately mounted; and satisfactory sets of experiments were then obtained by Mr. Sonntag, assisted by Mr. Radcliff. The pendulum beat nearly seconds; that is, rudely, 3607 beats in 3600 seconds of time. The readings were made when the knife-edge passed the zero point of the graduated arc. The interval of the readings was ten seconds, and eleven readings generally made a set. These observations were continued from September 26th until October 12th. They are yet unreduced, and I am therefore unable to announce to what conclusions they lead. I may mention that experiments were made by Mr. Sonntag and Professor Bond at the Cambridge Observatory, prior to the sailing of the Expedition; and that the instrument will be placed in Professor Bond's hands, for a repetition of the experiments at the same place. Upon removing the pendulum apparatus, a fine unifilar magnetometer was mounted upon a firm support in the centre of the observatory, and the scale-readings were recorded hourly every seventh day, and three times daily during the interval from November to March. The same instrument was subsequently used for obtaining several sets of experiments in declination, deflection, and vibration. A corresponding number of sets of experiments for the determination of dip were also made with a well-adjusted instrument. These latter four classes of observations were, with certain omissions, subsequently repeated at Cape Isabella on the west side of Smith Strait, at Netlik in Whale Sound, at Upernivik, and at Godhavn. All of these observations are yet unreduced. I may mention that the instruments were furnished to the Expedition by Professor Bache, Superintendent of the United States Coast Survey, under whose supervision the

constants had been carefully determined, and to whom the instruments will be returned for correction.

Near the observatory a suitable shelter was erected for a number of thermometers, which were read hourly every seventh day, and three times daily in the interval. These instruments were carefully compared at every 10° of temperature down to -40° , and these records were referred to a standard which was brought home, and has been placed in the hands of the maker, Mr. Tagliabue, for further comparison. Some of the instruments were manufactured by Mr. Green, of New York, and were a gift from the Smithsonian Institution; the remainder were presented by Mr. Tagliabue. These observations were continued during our stay at Port Foulke, from September, 1860, to July, 1861. Throughout the cruise a bi-hourly registry of atmospheric temperature was made with a single instrument, mounted on the vessel when at sea, and on a post upon the ice when in winter harbour. A like number of barometer-readings was also made and recorded. A careful record of meteorological phenomena, including direction and force of wind, and general atmospheric conditions, was kept up during the cruise. Although there has been no discussion made of these observations, yet there are some manifest general results which may interest you. Our winter was much milder than either of the winters 1853-54 and 1854-55, passed by Dr. Kane at Rensselaer Harbour, 20 miles further north. The weather was, unlike that experienced by Dr. Kane, generally stormy. North-east winds, frequently very strong, prevailed—a fact at least in part accounted for by the open water which was, during our stay at Port Foulke, constantly visible outside of the harbour; and it was, doubtless, due to the same fact, that we experienced a modification of temperature. March was the coldest month. It was during this month, and while absent at Rensselaer Harbour, that I recorded my lowest temperature, -68° Fahr. It is remarkable that on the same day the lowest temperature registered at Port Foulke was only -29° , and on the day previous, when I experienced a temperature of -66.5° near Rensselaer Harbour, the temperature at Port Foulke was -27° .

I have made at Port Foulke a valuable set of tidal observations, which will, when reduced, exhibit some interesting results. The average rise and fall was about eight feet. The readings were made to tenths of a foot, and at intervals of ten minutes. While at sea the temperature of the surface-water was registered bi-hourly. I had frequent occasion to regret that I did not have a deep-sea sounding apparatus, for the furnishing of which, through a misapprehension, I had relied upon the National Observatory. Geological and mineralogical collections have been brought from Port Foulke and vicinity, and from the west coasts of Smith Strait and Kennedy Channel. A few fossils were found in the limestone rocks of Capes Leidy and Frazer, and at other points of the coast of Kennedy Channel, north of latitude 80° . The difficulty of carrying geological specimens so great a distance upon a dog-sledge, will be appreciated by the Society. Our collections of specimens of natural history are extensive. They embrace dredgings from various points along the Greenland coast between Godhavn and Port Foulke, plants from all the localities visited, skins and skeletons of the principal mammals, skins of most of the Arctic birds, and a large number of skulls of Esquimaux. The reindeer were very numerous at Port Foulke. Upwards of 200 of them were shot by my party. The walrus, and seal of different varieties, were also abundant. During the summer several varieties of water-fowl frequented localities about our harbour. The most numerous of these were the little auk (*Uria alle*) and the eider-duck (*Somateria mollissima*), several hundreds of which were captured. From these sources I had no difficulty in constantly supplying my party with fresh food; and to this I attribute in a great measure our entire exemption from disease.

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The geographical results of the Expedition embrace a survey of the west coast-lines of North Baffin Bay, Smith Strait, and Kennedy Channel, including the discovery of a new channel or sound, opening westward from the centre of Smith Strait. This survey was made without reference to previous charts. It commences at latitude $76^{\circ} 30'$, and extends north to latitude $82^{\circ} 40'$, embracing a shore-line of about 1300 miles. I regret that I was not able to cross over to the eastern coast of Kennedy Channel, and, therefore, had no opportunity to confirm the observations of the sailor Morton, who, you will remember, was the person who reported to Dr. Kane the existence of open water in Kennedy Channel in June, 1854; also an eastern coast-line of that channel as far as latitude $80^{\circ} 56'$; beyond which point the party could not penetrate, in consequence of the open water. In 1854, while acting under the orders of Dr. Kane, I had made a survey of that portion of the west coast of Smith Strait lying between Capes Sabine and Frazer, but the unfavourable circumstances of that survey had occasioned some errors, which I am glad to have had opportunity to ascertain and correct. Our further geographical results embrace the completion of the survey of the coast-lines of Whale Sound, and the re-survey of all the coasts between Wolstenholme Sound and Littleton Island. In that survey is embraced a shore-line of about 600 miles. Of the five islands laid down on Captain Inglefield's and Dr. Kane's charts, as being in the mouth of Whale Sound, we could find only three.

In physical geography I have obtained some interesting materials. Soon after entering winter harbour, I made, in connexion with Mr. Sonntag, a survey of a glacier which approaches the sea through a valley opening from the head of the bay in which we wintered. This had been discovered by Dr. Kane, and by him named My Brother John's Glacier. Its face is nearly 2 miles from the sea, which it is gradually approaching. With the view of determining its rate of progress, we ascended to its upper surface, and carefully measured a base-line in its axis. From either end of this base-line angles were taken, connecting it with fixed objects upon the mountains on each side. Lateral stations were next established, and these were connected with the base-line, and with the before-mentioned fixed objects. The angles were repeated by me after an interval of eight months, and the result showed a downward movement of the glacier, amounting to 94 feet. In October I performed a journey upon this glacier and the *mer de glace* to the eastward of it, penetrating about 50 miles into the interior. Our angle of ascent was, at first, about six degrees, decreasing gradually to from one to two degrees. The surface was at first somewhat broken and irregular, but as we advanced it became smooth, and the ascent regular. Our elevation upon setting out to return was estimated at about 5000 feet, when we were quite out of sight of land.

The physical conditions observed in Kennedy Channel are, perhaps, among the most important of my results. It was in that channel, and to the northward of it, as I have before observed, that Morton discovered an open sea late in June, 1854. I did not find open water, but the ice was everywhere much decayed, often being so thin that it would not bear my party; and, in some places, pools of water were visible. In one of these pools a flock of water-fowl, the *Uria gryllæ*, were observed. My stay in Kennedy Channel was from the 12th to the 23rd of May, a period of the year six weeks earlier than that at which the observations of Morton had been made; and I entertain no doubt that, could I have returned to the same locality in the latter part of June, I would have found the sea open. Indeed, everything indicated a speedy dissolution of the ice. There were some indications also that the region to the northward is annually open. I will mention one which struck me most prominently. The coast on the west side of Kennedy Channel, especially where exposed to the north-east, was lined with a heavy ridge of ice, which had been forced up under the influence of great pressure. Many of the masses were

as much as 60 feet in height, and they were lying high and dry upon the beach. The pressure necessary to occasion this result could not possibly be created by ice-fields moving over a narrow channel, and I believe the result to have been produced by ice-fields of great extent coming down under the influence of winds and the current from a vast open area to the northward.

Our astronomical observations were chiefly confined to the determination of geographical positions.
